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WHITE PAPER

Offshore Wind Transmission: How Far Has the U.S. Come?

Strides are being made in the offshore wind transmission space, but to maximize the potential of this renewable energy source, interested parties from all relevant sectors must come together and agree on issues like oversight and how to connect offshore generation to the onshore electric grid in a scalable and sensible manner.

Offshore wind (OSW) power generation is one of the many clean energy sources that show great promise for the future. For us to find our path and integrate offshore wind transmission systems into the evolving onshore power grid, key interconnection, funding and oversight issues must be resolved.

In Sept. 2022, there were seven OSW turbines in operation. The Biden administration is aiming for 30 gigawatts of OSW generation by 2030. To meet this goal, 2,100 turbines would have to go online in eight years. That is a tall order, but one that could be reached if challenges are realistically discussed, delegated and dealt with.

However, challenges are generally not static. As the industry landscape changes, so do the barriers. 1898 & Co. first explored the issue of OSW transmission in a 2019 white paper. At that time, we recommended a framework for the definition and clarification of roles for all interested parties. As we look ahead to the future, this need has grown even more pressing.

The United States OSW transmission market is growing and maturing at breakneck speed. Consider the following:

CATEGORY	2019 (END)	2022 (MIDYEAR)
IN PROJECT PIPELINE	28.5 GW	40.1 GW
OPERATING	30 MW	42 MW
UNDER CONSTRUCTION	0 MW	932 MW
PURSUING PERMITS	13.47 GW	18.58 GW
LEVELIZED COST OF ENERGY (AVERAGE)	$132/MWh	$84/MWh
TURBINE ROTOR DIAMETER	150 m	236 m
NATIONAL GOALS	None nationally but 19 GW individual states combined	30 MW by 2030
LEASE AREAS	Since 2019, areas have been identified in California, Oregon, and in the Gulf of Mexico, the Central Atlantic and the Gulf of Maine.	

Figure 1: Offshore wind transmission metrics.

To stay on track with meeting aggressive OSW transmission goals, interested parties must rethink and reframe present critical path barriers to achieve the broader goal of connecting OSW to the electric grid. To spark that conversation, here are seven questions to consider.

1. Where will offshore generation connect to the onshore grid?

In the U.S., there are a limited number of locations that are well-suited to interconnect offshore generation to the existing onshore grid because of densely populated coastal communities, existing infrastructure and limited ocean access. In the last three years, OSW developers have submitted interconnection requests to these ideal points of interconnection, in some cases exhausting the available capacity (i.e., headroom) at those locations. When the headroom at a location is used, the location and its nearby electrical facilities will likely require costly upgrades to inject more power, making it much less attractive for future OSW interconnections.

This concept applies to the individual interconnecting substations, but it can also apply on a broader scale. For example, according to a published ISO-NE Economic Study report, the New England onshore grid likely has enough headroom to accommodate 5.8 GW of OSW without major 345-kV upgrades. This translates to approximately five or six utility-scale projects. After those interconnections are made, it could cost $1 billion or more for each additional OSW project to upgrade the grid for interconnection. New England states have already procured 4.7 GW of OSW, about one project shy of the estimated less-costly headroom.

Many have called for ideal interconnection locations to be reserved, prioritized and allocated to developers outside of the traditional framework: the first-come, first-served interconnection queue. Officials in New England states are taking action to address this issue in their area. On Sept. 1, 2022, five New England states along the Atlantic Ocean shoreline released a request for information (RFI) with an attached Modular Offshore Wind Integration Plan. This plan mentions that the participating states would control the efficient use of points of interconnection (POI). This control paired with the right planning would likely unlock much more total headroom across the system.

Beyond New England, some states have formulated policies to address this concern indirectly. For example, the New Jersey State Agreement Approach (SAA) will likely competitively procure a swath of transmission upgrades to the coastal electricity grid. The SAA epitomizes a state's ability to drive OSW developers toward optimal POI by either strategically reinforcing areas of the transmission grid onshore or developing junctions offshore that tie to the desired onshore POIs. States should continue to take more responsibility to steward points of interconnection for the long-term benefit of the industry.

2. How would an offshore grid integrate with the onshore grid?

In the past three years, there has been robust discussion about the various offshore grid configurations and how each would integrate with the existing transmission system onshore. The consensus: Individual generator lead lines may be the cheapest and simplest option for developers of the

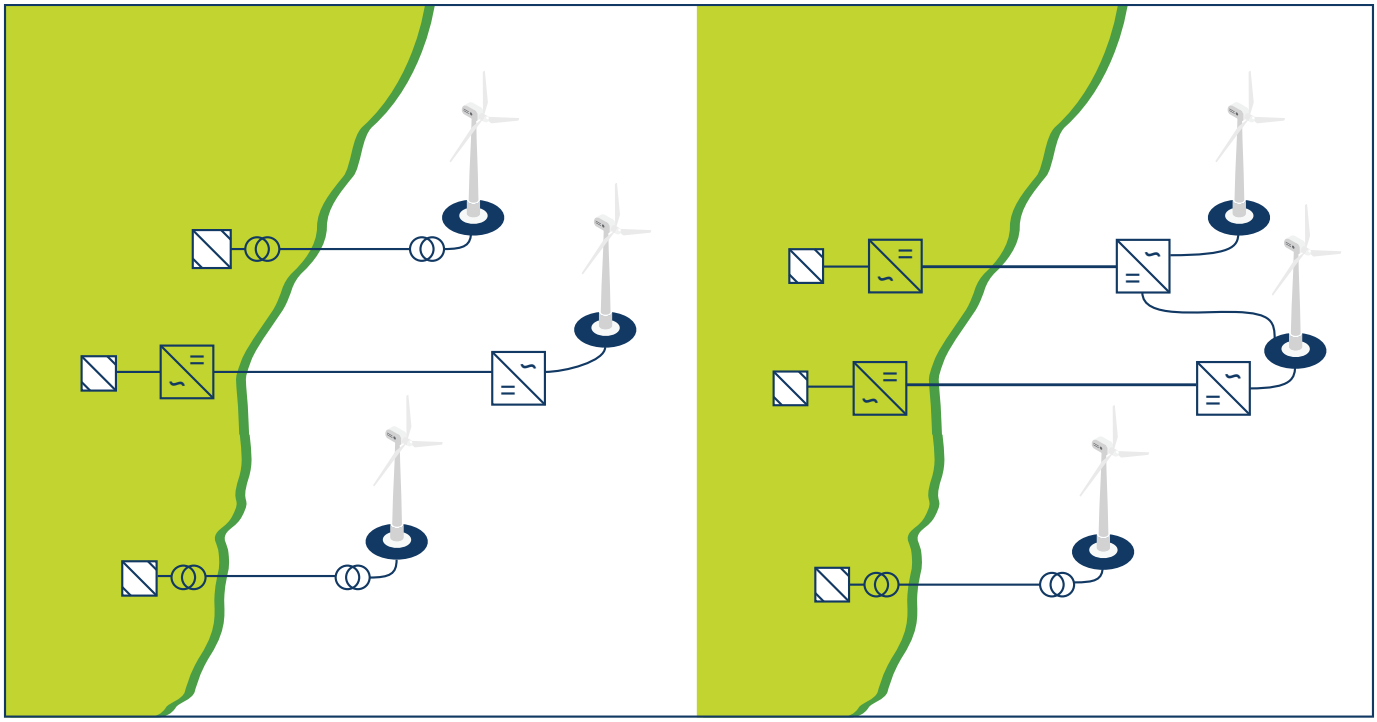

***Figure 2:** Offshore wind configurations: traditional radial connections (left) and meshed interconnections (right).*

first set of projects, but in the long term it could be more reliable, more efficient and cheaper to link or network certain projects together offshore. However, there is no consensus on the final form for that design.

New York has been a leading state in the debate around the offshore interconnection discussion. New York's "meshed-ready" provision in the newest round of procurement would require developers to design high voltage direct current (HVDC) export links, so they can be later linked offshore with high voltage alternating current (HVAC), allowing neighboring developers to partially share paths to shore.

The eventual deployment of a meshed grid seeks to reap benefits beyond simple generator lead line integration; it could add redundancy and potentially reduce congestion of a historically heavily congested area. The approach also saves the planning for a later stage of OSW deployment while requiring HVDC transmission (which uses fewer total cables than HVAC — a boon in heavily space-constrained areas).

Some are hesitant about the "meshed-ready" provision: There will be technical challenges associated with frequency and angle synchronization across geographically disparate offshore platforms. Additionally, without precise distances of the HVAC lines between platforms, (currently estimated at 20-40 miles), developers will not be able to accurately determine the platform space needed for reactive compensation devices at either end of the HVAC interlink cables. Technical challenges aside, it remains to be seen whether developers will be willing to risk degrading their equipment to deliver neighboring wind farms' power to New York.

On the other hand, New Jersey's SAA also considers the form of an offshore networked design but places the planning at the beginning of the process. The New Jersey Board of Public Utilities accepted proposals that included the design of offshore junctions or substations where developers could interconnect, effectively moving POIs offshore. Both New York and New Jersey have decided against leaving the final design of integration solely up to developers. This poses the next question on our list of seven:

3. Who will be responsible for transmission development?

A variety of approaches along the spectrum of private-public responsibility have emerged for offshore transmission development. The New Jersey SAA puts all the transmission development responsibility onto one party: the Request for Proposal winner(s). In New York, the New York State Energy Research and Development Authority (NYSERDA) will presumably select an entity to operate the HVAC interlinks between HVDC lines. Massachusetts may also follow New York and New Jersey, as the state legislature recently passed a bill to competitively solicit proposals for OSW transmission.

It seems that offshore generation developers will not be required to build out the more expensive parts of an offshore networked design. Even so, offshore design responsibility is just one piece of the puzzle. Transmission development will occur onshore in parallel with offshore development because, once connected, onshore and offshore transmission will all be one network. Currently, developers are responsible to mitigate onshore transmission adverse impacts associated with accommodating their injection of power. States can take responsibility for the onshore upgrades with proactive legislation and transmission development to relieve developers of this costly burden.

New York is currently reviewing proposals for the Long Island Public Policy Transmission Need (LI PPTN) to resolve the limited transmission capability from Long Island to the rest of the state. The LI PPTN has the potential to proactively transform Long Island into a landing zone for OSW rather than retroactively upgrading the onshore grid. A retroactive approach would lead to more variation in Offshore Wind Renewable Energy Certificate prices and longer construction lead times. Like Texas' CREZ and California's Tehachapi proactive transmission projects, the LI PPTN encourages development of renewables by reducing barriers to the market but looks to avoid system overdesign by waiting for projects to reach later stages of maturity. Other states with export limitations should prioritize proactive transmission development to avoid costly interconnections or delays down the line.

4. Who will manage the design, construction and interconnection process?

The management of the OSW design, construction and interconnection process will likely grow more complex as different parts of the interconnection are split into separate procurements. New York and New Jersey have already split generation and transmission, and the Massachusetts Legislature is following suit.

This trend will likely continue at the project level. It is expected that different parties will be hired under separate engineer-procure-construct (EPC) contracts to design and construct the wet components versus the dry, the transmission versus the structural, and the cabling versus the power electronics. Countless interfaces will exist between contracts, black boxes from vendors and the supply chain. Developers need to manage the flow of information, schedules and timely communication of changes in design between EPC contractors.

Without this big-picture management, projects will be constructed late with suboptimal or even flawed designs. Flawed projects could hamper the ultimate goal of an offshore network. What is the incentive to connect to a neighbor if a flaw in their design could jeopardize a developer's own ability to deliver power? Interoperability and compatibility must be meticulously tracked and managed among all parties of a project for cohesive overall design and project execution.

5. How will states and regional organizations coordinate together?

The U.S. is in the earliest stages of regional OSW coordination and does not yet have a national energy policy to guide design and cost allocation. Nevertheless, the federal government recognizes the need for federal involvement across regional transition operators' (RTO) borders. The Department of Energy (DOE) is leading the charge with the Building a Better Grid initiative: studying transmission planning on a national scale, leveraging federal financing tools and collaborating with interested parties that run the gamut from states to tribes to industry. DOE has funded the National Renewable Energy Laboratory to conduct the Atlantic OSW Transmission Study. While the study does not prescribe duties to RTOs, states, utilities or developers, it provides guidance on the design trajectory for the industry on the Eastern Seaboard.

Instead of thinking about the coordination process as entirely top-down or bottom-up, the industry must consider which strategy befits each facet of coordination. For instance, actionable interregional transmission planning begins with detailed local transmission planning. The Federal Energy Regulatory Commission (FERC) released an advanced notice of proposed rulemaking that indicates a shift toward longer-term planning. The agency may soon require RTOs to plan for a 20-year time horizon. Independently, California Independent System Operator has proactively begun 20-year transmission planning to see that all renewables in disparate areas of California can be integrated. This planning includes scenario analysis with different onshore and offshore reinforcement strategies. By comparing 20-year plans and examining the Atlantic OSW Transmission Study, RTOs can align long-term OSW integration goals.

Within RTOs, it is simpler for states to cooperate with each other. In releasing the OSW Transmission Integration RFI, New England states have taken the first two steps in Power Advisory LLC's Coordinated Transmission Development framework: First, the states have assessed benefits of coordinated transmission and, second, the collective has agreed to an overall approach.

The Modular Offshore Wind Integration Plan attached to the RFI seems to be in the earliest stages of soliciting a multistate offshore grid, using a phased approach. This document outlines a broad direction for the region's OSW integration

efforts, which can be refined with comments from interested parties. The RFI is the first of its kind in the U.S. and marks an exciting landmark in the coordination of states' OSW goals.

However, while a bottom-up approach may be a beneficial for transmission planning, many claim that implementing a meshed grid or offshore backbone would require RTO or federal leadership regarding aspects like cost allocation and onshore upgrade coordination. The Business Network for Offshore Wind has suggested a cost allocation model reminiscent of the federal highway system. FERC's Advance Notice of Proposed Rulemaking and its Atlantic OSW Transmission Study provide direction, but there is currently no federal effort to allocate costs across RTOs or a plan to coordinate onshore upgrades cohesively.

6. How will offshore transmission be regulated?

While progress has been made in determining how offshore and onshore transmission interconnects, there is still much uncertainty about how offshore transmission will be regulated. The two transmission development paths taken in New York and New Jersey spawn different questions surrounding regulation. In New Jersey, how involved will the Board of Public Utilities be in the enactment of the OSW transmission proposal after its selection? In New York, who will define interoperability of developers' export systems? How will developers be properly compensated for power transmitted through the shared grid and other developers' HVDC links? These and countless other regulatory uncertainties remain until the planning bodies move to implement network design.

7. How will transmission projects be financed?

Consistent permitting and state procurements have led to one utility-scale OSW project in construction and a substantial increase in the value per square mile of offshore lease areas off the East Coast. Some warn that a change in federal leadership or a delay of more than a year would have significant credit implications for these projects. Inflation, project costs and supply chain challenges all pose potential risks to OSW developers at this critical juncture. The costs of uncertainty and delays associated with these risks are magnified greatly in this investment climate.

The OSW transmission industry would benefit from more active financial institution voices in critical early conversations. As new and innovative regulatory constructs are being developed, it's important that the finance community have a seat at the table. Certain risk allocation and revenue models will lend themselves to broader financial institutions' support, something the OSW industry will need given the extensive capital required over the coming years.

Leaning more on supply chain partners, utility financing and government incentives could provide broader stability to the industry beyond contributions of capital and domain knowledge at the project level and could help the industry meet aggressive targets while advancing the pursuit of clean energy.

More to Come

While contemplating the future, there are even more OSW transmission questions to consider:

- How can fossil-fueled generators be retired strategically to minimize costs to ratepayers associated with OSW interconnection while also keeping the current owner whole?
- What role will energy storage play in reducing transmission needs onshore and offshore?
- Can lease auction revenue be reinvested back into federal OSW transmission efforts?
- How will the challenges of dynamic cables affect the floating generation of OSW?
- What research and development investments need to be made to enable multiterminal HVDC?
- How will the workforce be trained to promote the longevity of the industry?
- How can supply chain concerns be mitigated for materials sourcing?

To help this burgeoning industry, the U.S. government is subsidizing it heavily. The Infrastructure Investment and Jobs Act appropriates roughly $100 million through 2031 to DOE to conduct transmission planning, modeling and analyses for interregional and offshore wind transmission projects.

It is up to interested parties to regularly revisit challenges and finetune solutions that encourage federal support to grow and mature for the OSW industry. Developers, ratepayers and regulators must constantly reassess the needs of the market in order to optimize the benefits of offshore wind transmission in the U.S. long term.

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